Source Control Action Plan, Slip 4, Lower Duwamish Waterway

Task 2.3 – Soil and Groundwater Screening Criteria

The Washington Department of Ecology (Ecology) has requested SAIC to assist with the evaluation of properties in the Slip 4 drainage basin that are potential sources of sediment recontamination. As part of this effort, SAIC was tasked to develop soil and groundwater screening levels that could be used to identify upland properties which may pose a potential risk of recontamination of Slip 4 sediments. These screening levels may also be used to evaluate sediment recontamination risk for other Duwamish River drainage areas.

Upland contaminants may be transported to Duwamish River sediments in several ways, including the following:

- transport of contaminants in groundwater to Duwamish River sediments or surface water
- transport of contaminants in soil via desorption or dissolution to groundwater and subsequent transport to Duwamish River sediments or surface water
- direct release of contaminants in soil to the Duwamish River via erosion of upland soils or river banks

Draft screening levels have been developed for each of these pathways, as described in the following sections. These screening levels incorporate a number of conservative assumptions, including the absence of dilution, ample time for contaminant concentrations in soil, sediment, and groundwater to achieve equilibrium, and other assumptions as described in Section 1.1, below. In addition, the screening levels do not address issues of contaminant mass flux from upland to sediments nor do they address the area or volume of sediment that might be affected by upland contaminants. Because of these assumptions and uncertainties, we view these screening levels as most appropriately used for one-sided comparisons. If contaminant concentrations in upland soil or groundwater are below these screening levels, then it is unlikely that they will lead to exceedance of marine sediment Cleanup Screening Levels (CSLs). However, upland concentrations that exceed these screening levels *may or may not* pose a threat to marine sediments; additional site-specific information must be considered in order to make such an assessment.

1.0 Groundwater to Sediment Pathway

Some contaminants have a tendency to partition from groundwater into sediments. Given groundwater concentrations of these contaminants, the source control team needs to be able to evaluate quickly whether a particular site is a potential source of contamination to the sediments via groundwater. Ecology has identified a need for a table of values based on modeling that provides a range of concentrations (maximum/minimum) for contaminants of concern to assess sites with existing groundwater information. The Cleanup Screening Level (CSL) and Sediment Quality Standard (SQS) values identified in the Washington Sediment Management Standards

(WAC 173-204) were selected as target sediment concentrations (Table 1); groundwater screening levels (GWSLs) were calculated for the list of chemicals in Table III, WAC 173-204-520.

1.1 General Equations and Assumptions

The following relationship was used to calculate GWSLs for organic chemicals:

GWSL = (CSL [or SQS] / K_{oc}) x CF

Where:

GWSL = groundwater screening level (ug/L)
CSL = Cleanup Screening Level (WAC 173-204-520) (mg/kg OC)
SQS = Sediment Quality Standard (WAC 173-204-320) (mg/kg OC)
K_{oc} = organic carbon partition coefficient (L/kg OC)
OC = organic carbon
CF = conversion factor (1000 ug/mg)

This equation is based on the general definition of a partition coefficient. The organic carbon partition coefficient, K_{oc}, is defined as the ratio of the concentration of a chemical in water to its concentration in the organic carbon fraction of soil or sediment (Ecology 2001). By rearranging and converting units as necessary, a simplified relationship between contaminant concentration in sediment (in this case, the CSL) and a contaminant in groundwater (the GWSL) is obtained. This simplified relationship incorporates a variety of conservative assumptions, as described below.

For inorganic chemicals, GWSLs were calculated in an analogous fashion using the following equation:

GWSL = (CSL [or SQS] / K_d) x CF

Where:

GWSL = groundwater screening level (ug/L)
CSL = Cleanup Screening Level (WAC 173-204-520) (mg/kg)
SQS = Sediment Quality Standard (WAC 173-204-320) (mg/kg)
K_d = partition coefficient (L/kg)
CF = conversion factor (1000 ug/mg)

A variety of assumptions are inherent in the calculation of GWSLs. The model assumes no dilution of groundwater. It assumes that sediment is in direct contact with water at this concentration for a period of time long enough to achieve system equilibrium.

The calculated GWSLs do not take into consideration site-specific conditions, including distance of contaminants from discharge point, pH, temperature, grain size, and geochemical characteristics of the groundwater and sediment. These all contribute to uncertainty in the selection and application of appropriate screening levels.

1.1.1 K_{oc} Values

K_{oc} values were compiled from several sources, including both measured and modeled values (Table 2), as described below.

- **Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, U.S. Environmental Protection Agency, OSWER 9355.4-24 (December 2002)**

  EPA's 1996 Soil Screening Guidance Technical Background Document (USEPA 1996) summarized an extensive literature review conducted by EPA to identify all available measured K_{oc} values. Significant variability in the reported values was observed. Because measured K_{oc} values were available for only a subset of the compounds of interest, EPA developed an alternative methodology which was applied to the entire set of compounds of interest. The relationship between K_{ow} (octanol/water partition coefficient) and K_{oc}, as reported by Di Toro (1985), was used to calculate K_{oc} values for most semivolatile nonionizing organic compounds, as follows:

  $$\log K_{oc} = 0.00028 + (0.983 \times \log K_{ow})$$

  The calculated K_{oc} values were identified by EPA as default values for use in developing soil screening levels. For ionizing organic compounds, EPA predicted K_{oc} values from the partitioning of both ionized and neutral forms using the relationship described in Lee et al. (1990).

- **CLARC Database, WA Department of Ecology** (https://fortress.wa.gov/ecy/clarc/Reporting/CLARCReporting.aspx)

  The CLARC Database relies on the geometric mean of measured K_{oc} values, where available, as summarized in the 1996 Soil Screening Guidance Technical Background Document. For nonionizing organic compounds, the geometric mean of the literature K_{oc} values was used to represent the central tendency value. Where measured values were not available, the calculated K_{oc} values (using the DiToro correlation) were used. For ionizing organic compounds, the K_{oc} values modeled using the Lee et al. correlation, as described above, were used.

- **Estimation Programs Interface (EPI) Suite, V. 3.1.2, PCKOCWIN module, U.S. Environmental Protection Agency (December 2005)**

  EPA's Soil Adsorption Coefficient Program (PCKOCWIN) estimates K_{oc} for organic compounds based on the first-order molecular connectivity index (1-MCI) and a series of group contribution factors. The general equation used to estimate log Koc of any compound is:

  log Koc = 0.53 MCI + 0.62 + Summation (Pf)

  where MCI is the first order molecular connectivity index and Summation (Pf) is the summation product of all applicable correction factors. A list of the correction factors is presented in Appendix D to the software help file.

  After developing an extensive database of measured Koc values, the dataset was divided into a training set of 189 chemicals and an independent validation set of 205 chemicals (Meylan et al.). Two linear regressions were then performed: (1) measured log Koc values for nonpolar compounds in the training set were correlated with MCI; (2) the deviations between measured log Koc and the log Koc estimated with the nonpolar equation were correlated with the number of certain structural fragments in the polar compounds. The final equation for predicting log Koc accounts for 96% and 86% of the variation in the measured values for the training and validation sets, respectively (Meylan et al. 1992). Results show that the model outperforms and covers a wider range of chemical structures than do models based on Kow or water solubility.

  Chemicals that were included in the validation data sets are identified in Table 2. See Appendix E, Appendix F and Appendix G of the software help files for lists of the chemicals used in the regressions and a supplemental validation list.

Table 2 lists the maximum and minimum K_{oc} values that were identified, as well as the "best estimate" value used in the GWSL calculations. The "best estimate" values selected for the calculation of GWSLs are the EPI Suite modeled values because:

- in general, they showed greater consistency with measured values than did the K_{oc} values developed using the DiToro correlation;
- they were available for all of the SMS chemicals;
- they represent a consistent approach which is not dependent on laboratory or field measurement methodology and conditions.

It should be noted that for some chemicals, there is significant variability in the K_{oc} values shown in the table. For example, the difference between the maximum K_{oc} and the minimum K_{oc} is more than 2 orders of magnitude for some chemicals such as bis[2-ethylhexyl]phthalate and di-n-octyl phthalate. The groundwater screening levels calculated for these chemicals therefore also exhibit considerable variation.

1.1.2 K_d Values

K_d values are dependent upon on the nature of suspended solids or sediment and key geochemical parameters of the water (USEPA 2005b). Geochemical parameters that have the greatest influence on the magnitude of K_d include the pH of the system and the nature and concentration of sorbents associated with the soil/sediment or surface water (e.g., weight percent organic matter content, weight percent hydrous ferric oxides and corresponding oxides of aluminum and manganese). In addition, competition among metals for sorption sites and the resulting reduction in partition coefficients in multi-metal systems as opposed to single-metal systems has also been reported. The natural variability in soil/sediment composition and composition of associated porewater result in variations in K_d over several orders of magnitude, even for a single metal (USEPA 2005b).

Given these large variations, it should be noted that generic or default K_d values can result in significant error when used to predict contaminant migration at a given location. Therefore, while default values may be useful for preliminary screening purposes, K_d values measured at site-specific conditions are absolutely essential for site-specific contaminant transport and risk assessment calculations (USEPA 1999).

A recent EPA study (USEPA 2005b) used a two-phased approach to develop partition coefficients. First, a literature survey was conducted to determine the range and statistical distribution of values that have been observed in field studies, including the collection of published partition coefficients for the metals of interest and estimation of partition coefficients from reported metal concentration data. Measured values were presented for antimony, arsenic, cadmium, copper, lead, mercury, and zinc. The second phase included statistical methods, geochemical speciation modeling, and expert judgement to provide reasonable estimates of those K_d values not available from the literature search. A regression equation was developed to determine sediment K_d values from measured soil K_d values; this equation was used to derive K_d values for chromium III, chromium VI, nickel, and silver. These K_d values are listed in Table 3 and were selected for use in calculating GWSLs.

Additional K_d values were compiled from the following sources and are presented in the table; these were used to develop maximum and minimum K_d values.

- EPA Soil Screening Guidance (2002)
- CLARC database
- Baes and Sharp 1983 (A Proposal for Estimation of Soil Leaching and Leaching Constants for Use in Assessment Tools)
- Baes 1984 (A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture)
- Strenge & Peterson 1989 (Chemical Data Bases for the Multimedia Environmental Pollutant Assessment System)

As shown in Table 3, K_d values showed even greater variation than did the K_{oc} values described above. For example, K_d values for mercury and silver spanned over 3 orders of magnitude; only antimony, arsenic, chromium VI, and lead values varied by less than a factor of 100.

In addition to the uncertainties in K_d related to characteristics of the media, the methodology used to measure K_d in the field or laboratory also introduces significant uncertainty. The following factors contribute to this uncertainty (USEPA 2005b):

- Detection limits in measuring metal concentrations can result in limiting the observed maximum K_d value
- Equilibrium conditions may not have been present during batch experiments
- Different methods of measurement are used (e.g., batch experiments, measurements from natural soil/porewater, calculation from tracer/retardation studies)
- Extractants used in batch tests vary (e.g., porewater, groundwater, distilled water, electrolyte solutions)
- Redox conditions during experimental measurements may be uncontrolled or unknown, particularly for redox-sensitive metals such as arsenic and chromium
- Impacts of total system metal concentration are generally not evaluated in the published literature

1.2 Nonionizing Organics

Table 4 summarizes GWSLs calculated for nonionizing organic chemicals, based on both SQS and CSL values, including the range of GWSLs based on maximum and minimum K_{ow} values and the "best estimate" GWSL. For some chemicals, the large variation in K_{ow} values results in a very large range in the calculated GWSLs. For the following chemicals, the difference between maximum and minimum GWSL is greater than a factor of 10: bis(2-ethylhexyl)phthalate; di-n-butyl phthalate, di-n-octyl phthalate, hexachlorobenzene, and hexachlorobutadiene.

In addition, Table 4 provides a comparison of GWSLs to ambient water quality criteria (AWQC) for the protection of human health (consumption of organisms), Washington Marine Water Quality Criteria, EPA's Marine Chronic Water Quality Criteria for ecological receptors, and MTCA Method B groundwater cleanup levels. These values are used as screening levels for upland sites in the Portland Harbor Superfund Site source control program (except that the Washington marine water quality criteria are substituted with Oregon criteria). In most cases the calculated GWSLs are lower than the corresponding criteria, with several notable exceptions:

- the calculated GWSLs for polynuclear aromatic hydrocarbons (PAHs), except for dibenz(a,h)anthracene, are higher than the AWQC and MTCA Method B groundwater cleanup levels
- the calculated GWSLs for hexachlorobenzene exceed the AWQC and MTCA Method B groundwater cleanup levels

- the calculated GWSL for PCBs is higher than the AWQC by a factor of 3,000 to 20,000; it also exceeds the MTCA Method B groundwater cleanup level and the marine water quality criteria

The calculated GWSLs were also compared to typical method detection limits (MDLs) achievable using standard EPA analytical methods and to the lowest achievable MDLs using alternative analytical methods. The typical MDLs are not low enough to measure contaminants at the GWSL for most of the PAHs and phthalates, as well as dibenzofuran,1,2-dichlorobenzene, hexachlorobenzene, hexachlorobutadiene, N-nitrosodiphenylamine, and 1,2,4-trichlorobenzene. Lower detection limits are likely to be achievable using alternative analytical methods for all but benzo(g,h,i)perylene, dibenz(a,h)anthracene, and dibenzofuran.

1.3 Ionizing Organics

Ionizing organics are a special case because they contain functional groups that ionize under varying pH conditions; because the ionized and neutral species of these compounds have different sorption coefficients, models based solely on the partitioning of neutral species may not accurately predict sorption under different pH conditions.

As for nonionizing organics, the K_{oc} values predicted by EPA's EPI Suite were selected as best estimate values. It should be noted that for all chemicals, the EPI Suite K_{oc} value is higher than the corresponding CLARC/Soil Screening Guidance value at pH 6.8; this translates to a lower (e.g., more conservative) GWSL. Only benzoic acid shows a greater than 10-fold variation in calculated GWSLs.

Since the CSL and SQS values for ionizing organics are expressed in terms of dry weight and are not organic carbon normalized, the K_{oc} values were multiplied by an estimate of the average organic carbon content of Duwamish Waterway sediments (2%, or 0.02) (SEA 2004, Section 5.1.3.1).

Calculated GWSLs based on SQS and CSL values for nonionizing organics are presented in Table 4. Only the GWSL for pentachlorophenol exceeds the AWQC, marine water quality criteria, and Method B groundwater cleanup level. In addition, 4-methlphenol exceeds the MTCA Method B level. Typical MDLs are low enough for all ionizing organics except 2,4-dimethylphenol, 2-methlphenol, and pentachlorophenol; however, alternative analytical methods are available that would achieve MDLs below the calculated GWSLs.

1.4 Metals

Groundwater screening levels based on SQS and CSL values were calculated for the maximum, minimum, and best estimate K_d values, to provide a range of groundwater concentrations below which sediment recontamination is unlikely (Table 4).

It should be noted that the variation in GWSLs based on minimum and maximum K_d values is quite large; the following ratios of maximum to minimum GWSL are observed (rounded to two significant figures):

Arsenic:	70
Cadmium:	310
Chromium:	NA (only one K_d value was available)
Copper:	140
Lead:	40
Mercury:	8,000
Silver:	10,000
Zinc:	320

This large variation limits the usefulness of the GWSLs for metals for the purpose of screening upland properties to assess the potential for sediment recontamination. The AWQC and/or marine water quality criteria are lower than the calculated GWSLs for arsenic, chromium, copper, and lead, and may be appropriate alternative screening levels for these metals. For cadmium, mercury, silver, and zinc, the lowest calculated GWSLs, as shown in Table 4, may be appropriate.

MDLs are an issue only for mercury, however use of alternative analytical methods should alleviate this concern.

Many of the K_d values used to calculate GWSLs are based on field studies, however no information was readily available to indicate the methods used to derive the K_d values (e.g., methods used to prepare and analyze samples, etc.). In order to obtain this type of information, a research effort (beyond the scope of the current task) would be needed to review each of the individual field studies. Even if this information were obtained, the applicability of these studies to Duwamish Waterway upland sites is unclear.

2.0 Soil to Groundwater to Sediment Pathway

Contaminants in upland soil may percolate to groundwater and subsequently be transported to Slip 4 sediments or surface water, either below the ground surface via groundwater transport or by infiltration into storm drains and ditches that discharge to Slip 4 or other Lower Duwamish Waterway locations.

2.1 General Equations and Assumptions

GWSLs calculated in Section 1 above were used to develop soil screening levels (SSLs) protective of sediment recontamination, using the MTCA three-phase partitioning model described in WAC 173-340-747(4). The following equation was used:

$$SSL = GWSL \times UCF \times DF \times [K_d + (\theta_w + \theta_a H_{cc})/\rho_b]$$

Where:

SSL = soil screening level (mg/kg)
GWSL = groundwater screening level (ug/L), as shown in Tables 4 and 8

UCF = unit conversion factor (0.001 mg/ug)
DF = dilution factor (unitless); default of 20 for vadose zone soil, 1 for saturated zone soil)
K_d = distribution coefficient (L/kg; best estimate soil K_d values from Table 3)
θ_w = water-filled soil porosity (mL water/mL soil; default 0.3 for vadose zone soil, 0.43 for saturated zone soil)
θ_a = air-filled soil porosity (mL air/mL soil; default 0.13 for vadose zone soil, 0 for saturated zone soil)
H_{cc} = Henry's Law Constant (unitless)
ρ_b = dry soil bulk density (kg/L; default 1.5 kg/L)

SSLs were calculated for dilution factors of 1 (which represents saturated zone soil) and 20 (which represents vadose zone soil).

For organics, the K_d value was estimated as follows:

$$K_d = K_{oc} \times f_{oc}$$

Where:

K_{oc} = organic carbon partition coefficient (L/kg OC; from Table 2)
f_{oc} = organic carbon fraction of the soil; a default value of 0.1% (0.001 g/g) was used, per the MTCA Cleanup Regulation, Equation 747-2.

Default values for vadose zone and saturated zone soils were used, as specified in the MTCA Cleanup Regulation. Henry's Law Constants were obtained from EPA's EPI Suite software program (Table 5). The software estimates a Henry's Law Constant by using the estimation engine from Syracuse Research Corporation's HENRYWIN for Windows program. HENRYWIN also automatically retrieves experimental values from a database with reliably measured values. When a structure matches a database structure (via an exact atom-to-atom connection match), the experimental H value is retrieved and used to predict H rather than the estimated value. When there is no experimental value, HENRYWIN estimates H by using two methods: the Bond Method and Group Method. The experimental value is selected first, then the Group method and finally the Bond Method. HENRYWIN converts a log gamma value to the unitless and atm-m3/mole units as follows. The unitless value is obtained by taking the anti-log of the log gamma value and inverting the result.

For metals, Henry's Law Constant was set to 0, except for mercury (0.47), per WAC 173-340-747(4)(c)(ii)(d).

2.2 Organic Contaminants

Calculated SSLs for nonionizing organics based on SQS and CSL values are shown in Tables 6 and 7 for dilution factors of 20 and 1, respectively. SSLs were calculated using minimum and maximum GWSLs in addition to the best estimate values. The SSLs show much less variation between minimum and maximum values than do the GWSLs; this is partially because the same

K_{oc} value is used to partition a contaminant from soil to groundwater as from groundwater to sediment (e.g., if the two models were combined into a single equation, the K_{oc} value would appear in both the numerator [adjusted based on porosity, H, and soil bulk density] and the denominator). Only chemicals that have a very low Koc (such as benzoic acid, benzyl alcohol, and diethyl phthalate) show much variation in the calculated SSL.

The SSLs were compared to MTCA Method B and Method C soil cleanup levels. All SSLs were below Method C cleanup levels. For a few chemicals (PAHs and PCBs), the MTCA Method B soil cleanup level is more conservative than the calculated SSL. MDLs do not appear to be an issue for soil, except possibly for PCBs. An alternative analytical method may be necessary to achieve an MDL below the SSL for PCBs.

The calculated SSLs were also compared to sediment CSLs converted to a dry weight basis (assuming a sediment organic carbon content of 2%) (Table 6). For most chemicals, the SSLs are very similar to the converted CSLs. Those chemicals with very low K_{oc} values show the greatest difference between SSLs and dry weight CSLs.

2.3 Metals

Soil screening levels based on SQS and CSL values were calculated for the maximum, minimum, and best estimate GWSLs (Tables 6 and 7). Unlike organics, the SSLs for metals show very large variation between maximum and minimum screening levels (ranging from a factor of 2,000 for lead to a factor of over 6E+7 for silver), due to the underlying variability in K_d values. For arsenic and chromium, SSLs exceed the RCRA Method B soil cleanup levels. The large variation in SSLs for metals limits their usefulness for the purpose of screening upland properties to assess the potential for sediment recontamination.

3.0 Soil to Sediment Pathway

Contaminants in soil may be released directly to Slip 4 via erosion of upland soils or riverbanks. To screen contaminant concentrations in soil for this pathway, the dry-weight CSL or SQS values (as shown in Table 6) are recommended.

4.0 References

Baes, C.F. and Sharp, R.D. 1983. A Proposal for Estimation of Soil Leaching and Leaching Constants for Use in Assessment Tools. Journal of Environmental Quality, Vol. 12 No. 1, pp. 17-28.

Baes, C.F. 1984. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture.

DiToro, D.M. 1985. A Particle Interaction Model of Reversible Organic Chemical Sorption. *Chemosphere*. Vol. 14, pp. 1503-1538.

Ecology (Washington State Department of Ecology). 2001. Washington's Model Toxics Control Act (MTCA), Soil to Groundwater Exposure Pathway, Chapter 173-340-747 WAC. Powerpoint Presentation, June 20, 2001. http://www.ecy.wa.gov/PROGRAMS/tcp/regs/training/Fate_and_Transport/Exposure_Pathways/June%2020,%202001%20NWETC%20Presentation.ppt

Lee, L.S., P.S.C. Rao, P. Nkedi-Kizza, and J.J. Delfino. 1990. Influence of solvent and sorbent characteristics on distribution of pentachlorophenol in octanol-water and soil-water systems. *Environ. Sci. Tech.* 25:654-661. As cited in USEPA 1996.

Meylan, W., P.H. Howard, and R.S. Boethling. 1992. Molecular Topology/Fragment Contribution Method for Predicting Soil Sorption Coefficients. *Environ. Sci. Technol.* 26:1560-7.

Strenge, D.L. and S.R. Peterson. 1989. Chemical Data Bases for the Multimedia Environmental Pollutant Assessment System. MEPAS Version 1. Pacific Northwest Laboratory, Richland, Washington.

Striplin Environmental Associates, Inc. (SEA). 2004. Slip 4 Summary of Information and Data Gaps Report. January 15, 2004.

USEPA. 2006. National Recommended Water Quality Criteria. U.S. Environmental Protection Agency, Office of Water.

USEPA. 2005a. EPA Estimation Programs Interface (EPI) Suite, V. 3.12. U.S. Environmental Protection Agency. http://www.epa.gov/opptintr/exposure/pubs/episuite.htm. December

USEPA. 2005b. Partition Coefficients for Metals in Surface Water, Soil, and Waste. U.S. Environmental Protection Agency. EPA/600/R-05/074. July.

USEPA. 2002. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. OSWER 9355.4-24. December.

USEPA. 1999. Understanding Variation in Partition Coefficient, K_d, Values. U.S. Environmental Protection Agency, Office of Air and Radiation. EPA 402-R-99-004A. August.

USEPA. 1996. Soil Screening Guidance: Technical Background Document. U.S. Environmental Protection Agency. EPA/540/R95/128. May.

USEPA. 1994. Composite Model for Leachate Migration with Transformation Products (EPACMTP). U.S. Environmental Protection Agency. April.

Washington Administrative Code. WAC 173-201A-240, Toxic Substances, Table 240(3).

Washington Administrative Code. Marine Sediment Quality Standards: WAC 173-204-320, Table I and III.

Washington State Department of Ecology. CLARC Database: https://fortress.wa.gov/ecy/clarc/Reporting/CLARCReporting.aspx

Table 1. Regulatory Sediment Levels (SQS and CSL)

August 2006

Chemical	CAS No.	Class	SQS (mg/kg OC)	CSL (mg/kg OC)
acenaphthene	83-32-9	LPAH	16	57
acenaphthylene	208-96-8	LPAH	66	66
anthracene	120-12-7	LPAH	220	1200
benzo(g,h,i)perylene	191-24-2	HPAH	31	78
benzo[a]anthracene	56-55-3	HPAH	110	270
benzo[a]pyrene	50-32-8	HPAH	99	210
benzo[b]fluoranthene (a)	205-99-2	HPAH	230	450
benzo[k]fluoranthene (a)	207-08-9	HPAH	230	450
bis(2-ethylhexyl) phthalate	117-81-7	phth	47	78
butyl benzyl phthalate	85-68-7	phth	4.9	64
chrysene	218-01-9	HPAH	110	460
dibenz[a,h]anthracene	53-70-3	HPAH	12	33
dibenzofuran	132-64-9	misc extr	15	58
di-butyl phthalate (di-n-butyl phth.)	84-74-2	phth	220	1700
dichlorobenzene, 1,2-	95-50-1	chlor org	2.3	2.3
dichlorobenzene, 1,4-	106-46-7	chlor org	3.1	9
diethyl phthalate	84-66-2	phth	61	110
dimethyl phthalate	131-11-3	phth	53	53
di-n-octyl phthalate	117-84-0	phth	58	4500
fluoranthene	206-44-0	HPAH	160	1200
fluorene	86-73-7	LPAH	23	79
hexachlorobenzene	118-74-1	chlor org	0.38	2.3
hexachlorobutadiene	87-68-3	misc extr	3.9	6.2
indeno[1,2,3-cd]pyrene	193-39-5	HPAH	34	88
methylnaphthalene, 2-	91-57-6	LPAH	38	64
naphthalene	91-20-3	LPAH	99	170
nitrosodiphenylamine, N-	86-30-6	misc extr	11	11
pcb mixtures (b)	1336-36-3	PCBs	12	65
pcb - Aroclor 1016 (b)	12674-11-2	PCBs	12	65
pcb - Aroclor 1248 (b)	12672-29-6	PCBs	12	65
pcb - Aroclor 1254 (b)	11097-69-1	PCBs	12	65
pcb - Aroclor 1260 (b)	11096-82-5	PCBs	12	65
phenanthrene	85-01-8	LPAH	100	480
pyrene	129-00-0	HPAH	1000	1400
trichlorobenzene, 1,2,4-	120-82-1	chlor org	0.81	1.8

Sources:

SQS (Marine Sediment Quality Standards): WAC 173-204-320, Table I
CSL (Puget Sound Marine Sediment Cleanup Levels): WAC 173-204-320, Table III

(a) Criteria apply to the sum of benzo(b)fluoranthene and benzo(k)fluoranthene
(b) Criteria apply to total PCBs

Table 1. Regulatory Sediment Levels (SQS and CSL)

Chemical	CAS No.	Class	SQS (mg/kg)	CSL (mg/kg)
Antimony	7440-36-0	metal		
Arsenic, inorganic	7440-38-2	metal	57	93
Cadmium	7440-43-9	metal	5.1	6.7
Chromium +3	16065-83-1	metal		
Chromium +6	18540-29-9	metal		
Chromium, total	7440-47-3	metal	260	270
Copper	7440-50-8	metal	390	390
Lead	7439-92-1	metal	450	530
Mercury	7439-97-6	metal	0.41	0.59
Nickel	7440-02-0	metal		
Silver	7440-22-4	metal	6.1	6.1
Zinc	7440-66-6	metal	410	960

Chemical	CAS No.	Class	SQS (ug/kg)	SQS (mg/kg)	CSL (ug/kg)	CSL (mg/kg)
benzoic acid	65-85-0	misc extr	650	0.65	650	0.65
benzyl alcohol	100-51-6	misc extr	57	0.057	73	0.073
dimethylphenol, 2,4-	105-67-9	phenol	29	0.029	29	0.029
methylphenol, 2- (o-cresol)	95-48-7	phenol	63	0.063	63	0.063
methylphenol, 4- (p-cresol)	106-44-5	phenol	670	0.67	670	0.67
pentachlorophenol	87-86-5	phenol	360	0.36	690	0.69
phenol (total)	108-95-2	phenol	420	0.42	1200	1.2

Table 2. Koc Values

Chemical - Nonionizing Organics	CAS No.	K_{oc} (L/kg OC) (SSG 2002) (a)	K_{oc} (L/kg OC) (CLARC; SSG 1996) (b,c)	K_{oc} (L/kg OC) (EPI Suite) (d)	EPI Suite - Validated (d)	Best Estimate K_{oc} (L/kg OC) (e)	Max Koc (L/kg OC)	Min Koc (L/kg OC)	Max Koc/ Min Koc
acenaphthene	83-32-9	7.08E+03	4.90E+03	6.12E+03	YES	6.12E+03	7.08E+03	4.90E+03	1
acenaphthylene	208-96-8			6.12E+03		6.12E+03	6.12E+03	6.12E+03	1
anthracene	120-12-7	2.95E+04	2.35E+04	2.04E+04		2.04E+04	2.95E+04	2.04E+04	1
benzo(g,h,i)perylene	191-24-2			2.68E+06		2.68E+06	2.68E+06	2.68E+06	1
benzo[a]anthracene	56-55-3	3.98E+05	3.58E+05	4.27E+05		4.27E+05	4.27E+05	3.58E+05	1
benzo[a]pyrene	50-32-8	1.02E+06	9.69E+05	7.87E+05		7.87E+05	1.02E+06	7.87E+05	1
benzo[b]fluoranthene	205-99-2	1.23E+06	1.20E+06	8.03E+05		8.03E+05	1.23E+06	8.03E+05	2
benzo[k]fluoranthene	207-08-9	1.23E+06	1.20E+06	7.87E+05		7.87E+05	1.23E+06	7.87E+05	2
bis(2-ethylhexyl) phthalate	117-81-7	1.51E+07	1.11E+05	1.65E+05		1.65E+05	1.51E+07	1.11E+05	136
butyl benzyl phthalate	85-68-7	5.75E+04	1.37E+04	9.36E+03		9.36E+03	5.75E+04	9.36E+03	6
chrysene	218-01-9	3.98E+05	3.98E+05	2.36E+05		2.36E+05	3.98E+05	2.36E+05	2
dibenz[a,h]anthracene	53-70-3	3.80E+06	1.79E+06	2.62E+06		2.62E+06	3.80E+06	1.79E+06	2
dibenzofuran	132-64-9			1.13E+04		1.13E+04	1.13E+04	1.13E+04	1
di-butyl phthalate (di-n-butyl phth.)	84-74-2	3.39E+04	1.57E+03	1.46E+03	YES	1.46E+03	3.39E+04	1.46E+03	23
dichlorobenzene, 1,2-	95-50-1	6.17E+02	3.79E+02	4.43E+02	YES	4.43E+02	6.17E+02	3.79E+02	2
dichlorobenzene, 1,4-	106-46-7	6.17E+02	6.16E+02	4.34E+02	YES	4.34E+02	6.17E+02	4.34E+02	1
diethyl phthalate	84-66-2	2.88E+02	8.20E+01	1.26E+02	YES	1.26E+02	2.88E+02	8.20E+01	4
dimethyl phthalate	131-11-3			3.71E+02	YES	3.71E+02	3.71E+02	3.71E+02	1
di-n-octyl phthalate	117-84-0	8.32E+07	8.32E+07	1.96E+05		1.96E+05	8.32E+07	1.96E+05	424
fluoranthene	206-44-0	1.07E+05	4.91E+04	7.09E+04		7.09E+04	1.07E+05	4.91E+04	2
fluorene	86-73-7	1.38E+04	7.71E+03	1.13E+04		1.13E+04	1.38E+04	7.71E+03	2
hexachlorobenzene	118-74-1	5.50E+04	8.00E+04	3.38E+03	YES	3.38E+03	8.00E+04	3.38E+03	24
hexachlorobutadiene	87-68-3	5.37E+04	5.37E+04	9.94E+02		9.94E+02	5.37E+04	9.94E+02	54
indeno[1,2,3-cd]pyrene	193-39-5	3.47E+06	3.47E+06	2.68E+06		2.68E+06	3.47E+06	2.68E+06	1
methylnaphthalene, 2-	91-57-6			2.09E+03	YES	2.09E+03	2.09E+03	2.09E+03	1
naphthalene	91-20-3	2.00E+03	1.19E+03	1.84E+03	YES	1.84E+03	2.00E+03	1.19E+03	2
nitrosodiphenylamine, N-	86-30-6	1.29E+03	1.29E+03	5.62E+03		5.62E+03	5.62E+03	1.29E+03	4
pcb mixtures	1336-36-3		3.09E+05	4.48E+04	YES	4.48E+04	3.09E+05	4.48E+04	7
pcb - Aroclor 1016 (f)	12674-11-2		1.07E+05	2.71E+04		2.71E+04	1.07E+05	2.71E+04	4
pcb - Aroclor 1248	12672-29-6			4.39E+04		4.39E+04	4.39E+04	4.39E+04	1
pcb - Aroclor 1254	11097-69-1			7.56E+04		7.56E+04	7.56E+04	7.56E+04	1
pcb - Aroclor 1260 (f)	11096-82-5		8.22E+05	2.07E+05		2.07E+05	8.22E+05	2.07E+05	4
phenanthrene	85-01-8			2.08E+04	YES	2.08E+04	2.08E+04	2.08E+04	1
pyrene	129-00-0	1.05E+05	6.80E+04	6.94E+04	YES	6.94E+04	1.05E+05	6.80E+04	2
trichlorobenzene, 1,2,4-	120-82-1	1.78E+03	1.66E+03	7.18E+02		7.18E+02	1.78E+03	7.18E+02	2

Chemical -- Ionizing Organics	CAS No.	K_{oc} (L/kg) (SSG 2002 and CLARC), pH 6.8 (a,b)	K_{oc} (L/kg) (EPI) (d)	EPI Suite - Validated (d)	K_{oc} (L/kg OC) (e)	Max Koc	Min Koc	Max Koc/ Min Koc
benzoic acid	65-85-0	5.76E-01	1.45E+01		1.45E+01	1.45E+01	5.76E-01	25
benzyl alcohol	100-51-6		1.57E+01	YES	1.57E+01	1.57E+01	1.57E+01	1
dimethylphenol, 2,4-	105-67-9	2.09E+02	7.18E+02		7.18E+02	7.18E+02	2.09E+02	3
methylphenol, 2- (o-cresol)	95-48-7	9.12E+01	4.43E+02		4.43E+02	4.43E+02	9.12E+01	5
methylphenol, 4- (p-cresol)	106-44-5		4.34E+02		4.34E+02	4.34E+02	4.34E+02	1
pentachlorophenol	87-86-5	5.92E+02	3.38E+03	YES	3.38E+03	3.38E+03	5.92E+02	6
phenol (total)	108-95-2	2.88E+01	2.68E+02		2.68E+02	2.68E+02	2.88E+01	9

Notes:

(a) SSG 2002: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites, OSWER 9355.4-24, December 2002.
(b) CLARC database: WA Department of Ecology; https://fortress.wa.gov/ecy/clarc/Reporting/CLARCReporting.aspx
(c) SSG 1996: Soil Screening Guidance: Technical Background Document, EPA/540/R95/128, May 1996
(d) EPI: EPA Estimation Programs Interface (EPI) Suite, V. 3.12, December 2005. Values were taken from http://www.epa.gov/oppt/exposure/docs/episuitedl.htm. See Section 1.1.1 for additional information.
(e) Koc used for screening level calculations; see text.
(f) CLARC source listed as Soil Screening Guidance 1994; this source could not be located to determine whether this is a measured or modeled value

(yellow)	Max K_{oc} is at least a factor of 10 greater than Min K_{oc} (e.g., large variation in K_{oc} values)
(orange)	modeled value
. (cyan)	measured value
(grey)	best estimate value

Table 3. Kd Values

Chemical	CAS No.	K_d (L/kg) EPA 2005 (Sediment) (a)	K_d (L/kg) (SSG), pH 6.8 (b)	K_d (L/kg), CLARC (c)	K_d (L/kg) EPA 2005 (Soil) (a)	K_d (L/kg) EPA 1994 (d)	K_d (L/kg) Baes 1983 (e)	K_d (L/kg) (Baes 1984) (f)	K_d (L/kg) Strenge & Peterson 1989 (g)	Selected Sediment K_d (L/kg) (h)	Selected Soil K_d (L/kg) (h)	Min K_d (L/kg)	Max K_d (L/kg)	Max Kd/ Min Kd
Antimony	7440-36-0	3.98E+03	4.50E+01	4.50E+01	2.00E+02			4.50E+01		3.98E+03	2.00E+02	4.50E+01	3.98E+03	88
Arsenic, inorganic	7440-38-2	2.51E+02	2.90E+01	2.90E+01	1.58E+03				2.15E+01	2.51E+02	1.58E+03	2.15E+01	1.58E+03	74
Cadmium	7440-43-9	2.00E+03	7.50E+01	6.70E+00	5.01E+02		6.70E+00	6.50E+00	1.20E+02	2.00E+03	5.01E+02	6.50E+00	2.00E+03	307
Chromium +3	16065-83-1	7.94E+04	1.80E+06	1.00E+03	6.31E+03					7.94E+04	6.31E+03	1.00E+03	1.80E+06	1800
Chromium +6	18540-29-9	5.01E+01	1.90E+01	1.90E+01	6.31E+00					5.01E+01	6.31E+00	6.31E+00	5.01E+01	8
Chromium, total	7440-47-3							8.50E+02		8.50E+02	8.50E+02	8.50E+02	8.50E+02	1
Copper	7440-50-8	3.16E+03		2.20E+01	3.16E+02		2.20E+01	3.50E+01	3.36E+02	3.16E+03	3.16E+02	2.20E+01	3.16E+03	144
Lead	7439-92-1	3.98E+04		1.00E+04	5.01E+03	1.00E+04		9.00E+02	1.83E+03	3.98E+04	5.01E+03	9.00E+02	3.98E+04	44
Mercury	7439-97-6	7.94E+04	5.20E+01	5.20E+01	3.98E+03			1.00E+01	5.28E+03	7.94E+04	3.98E+03	1.00E+01	7.94E+04	7943
Nickel	7440-02-0	7.94E+03	6.50E+01	6.50E+01	7.94E+02			1.50E+02		7.94E+03	7.94E+02	6.50E+01	7.94E+03	122
Silver	7440-22-4	3.98E+03	8.30E+00	8.30E+00	3.98E+02			4.50E+01	4.00E-01	3.98E+03	3.98E+02	4.00E-01	3.98E+03	9953
Zinc	7440-66-6	1.26E+04	6.20E+01	6.20E+01	5.01E+02			4.00E+01	1.46E+03	1.26E+04	5.01E+02	4.00E+01	1.26E+04	315

Sources:

(a) EPA 2005. Partition Coefficients for Metals in Surface Water, Soil, and Waste. EPA/600/R-05/074. July 2005.
(b) SSG: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24. Exhibit C-4. December 2002.
(c) CLARC database: WA Department of Ecology; https://fortress.wa.gov/ecy/clarc/Reporting/CLARCReporting.aspx
(d) EPA 1994. Composite Model for Leachate Migration with Transformation Products (EPACMTP). U. S. Environmental Protection Agency. April 1994.
(e) Baes 1983. Baes, C.F. and R.D. Sharp. A Proposal for Estimation of Soil Leaching and Leacing Constants for Use in Assessment Tools, Journal of Environmental Quality, Vol. 12, No. 1, pp. 17-28, 1983
(f) Baes 1984. Baes, C.F. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture. (http://homer.ornl.gov/baes/documents/ornl5786.html)
(g) Strenge & Peterson 1989, Table 4.1.
(h) K_d used for screening level calculations; see text.

Max K_d is at least a factor of 10 greater than Min K_{oc} (e.g., large variation in K_d values)
modeled value
. measured value

Table 4. Summary of Groundwater Screening Levels (Based on Sediment SQSs)

August 2006 (revised February2007)

Chemical	Range of GW Screening Levels Based on SQS (ug/L)	GWSL based on SQS and best estimate K_{oc}/K_d (ug/L)	Range of GW Screening Levels Based on CSL (ug/L)	GWSL based on CSL and best estimate Koc/Kd (ug/L)	AWQC (ug/L) (HH; organism only) (a)	WA Marine Water Quality Criteria (b)	EPA Marine Chronic Water Quality Criteria (ecological receptors; ug/L) (a)	MTCA Method B GW Cleanup Level (ug/L)	Typical Method Detection Limit (MDL) (ug/L) (c)	Lowest Method Detection Limit (MDL) (ug/L) (d)	Analytical Method that will Achieve GWSL (e)	Ratio of AWQC to GWSL	Ratio of Max to Min GWSLs
acenaphthene	2.3 to 3.3	2.6	8.1 to 11.6	9.3	990			960	10	1.8	EAD 610	379	1.4
acenaphthylene	11 to 11	11	11 to 11	11					10				1.0
anthracene	7.5 to 11	11	41 to 59	59	40,000			4800	10			3709	1.4
benzo(g,h,i)perylene	0.012 to 0.012	0.012	0.029 to 0.029	0.029					10	0.05	NERL 550		1.0
benzo[a]anthracene	0.26 to 0.31	0.26	0.63 to 0.76	0.63	0.018			0.012	10	0.004	NERL 550.1	0.070	1.2
benzo[a]pyrene	0.10 to 0.13	0.13	0.21 to 0.27	0.27	0.018			0.012	10	0.032	NERL 525.2	0.14	1.3
benzo[b]fluoranthene	0.19 to 0.29	0.29	0.37 to 0.56	0.56	0.018			0.012	10	0.006	NERL 550.1	0.063	1.5
benzo[k]fluoranthene	0.19 to 0.29	0.29	0.37 to 0.57	0.57	0.018			0.012	10	0.003	NERL 550.1	0.062	1.6
bis(2-ethylhexyl) phthalate	0.0031 to 0.42	0.28	0.0052 to 0.70	0.47	2.2			6.3	10	0.46	NERL 525.2	7.7	136
butyl benzyl phthalate	0.085 to 0.52	0.52	1.1 to 6.8	6.8	1,900			3200	10	0.025	NERL 525.2	3629	6.1
chrysene	0.28 to 0.47	0.47	1.2 to 1.9	1.9	0.018			0.012	10	0.063	NERL 550	0.039	1.7
dibenz[a,h]anthracene	0.0032 to 0.0067	0.0046	0.0087 to 0.018	0.013	0.018			0.012	10	0.035	NERL 550.1	3.9	2.1
dibenzofuran	1.3 to 1.3	1.3	5.1 to 5.1	5.1				32	10	10	EPA 8270D		1.0
di-butyl phthalate (di-n-butyl phth.)	6.5 to 151	151	50 to 1164	1164	4,500			1600	10			30	23
dichlorobenzene, 1,2-	3.7 to 6.1	5.2	3.7 to 6.1	5.2	1,300			720	10	0.02	EPA 8021B	250	1.6
dichlorobenzene, 1,4-	5.0 to 7.1	7.1	15 to 21	21	190			1.8	10	0.02	EPA 8021B	27	1.4
diethyl phthalate	212 to 744	484	382 to 1341	873	44,000			13000	10			91	3.5
dimethyl phthalate	143 to 143	143	143 to 143	143	1,100,000			16000	10			7700	1.0
di-n-octyl phthalate	0.00070 to 0.30	0.30	0.054 to 23	23				320	10	0.049	EPA 8061A		424
fluoranthene	1.5 to 3.3	2.3	11 to 24	17	140			640	10	0.009	NERL 550.1	62	2.2
fluorene	1.7 to 3.0	2.0	5.7 to 10	7.0	5,300			640	10	0.059	NERL 525.2	2604	1.8
hexachlorobenzene	0.0048 to 0.11	0.0048	0.029 to 0.68	0.029	0.00029			0.055	10	0.001	OGWDW 551.1	0.0604	24
hexachlorobutadiene	0.073 to 3.9	3.9	0.12 to 6.2	6.2	18			0.56	10	0.02	EPA 8021B	4.6	54
indeno[1,2,3-cd]pyrene	0.010 to 0.013	0.013	0.025 to 0.033	0.033	0.018			0.012	10	0.011	NERL 550	1.4	1.3
methylnaphthalene, 2-	18 to 18	18	31 to 31	31				32	10				1.0
naphthalene	50 to 83	54	85 to 143	92				160	10				1.7
nitrosodiphenylamine, N-	2.0 to 8.5	2.0	2.0 to 8.5	2.0	6.0				10	0.81	EAD 607	3.1	4.4
pcb mixtures	0.039 to 0.27	0.27	0.21 to 1.5	1.5	0.000064	0.030	0.03	0.044	0.1			0.00024	6.9
pcb - Aroclor 1016	0.11 to 0.44	0.44	0.61 to 2.4	2.4				1.1	0.08				3.9
pcb - Aroclor 1248	0.27 to 0.27	0.27	1.5 to 1.5	1.5					0.1				1.0
pcb - Aroclor 1254	0.16 to 0.16	0.16	0.86 to 0.86	0.86				0.32	0.1				1.0
pcb - Aroclor 1260	0.015 to 0.06	0.058	0.079 to 0.31	0.31					0.2	0.018	NERL 525.2		4.0
phenanthrene	4.8 to 4.8	4.8	23 to 23	23					10	0.059	NERL 525.2		1.0
pyrene	10 to 15	14	13 to 21	20	4,000			480	10			278	1.5
trichlorobenzene, 1,2,4-	0.46 to 1.1	1.1	1.0 to 2.5	2.5	70			80	10	0.02	NERL 502.2	62	2.5
benzoic acid	2243 to 56424	2243	2243 to 56424	2243				64000	50				25
benzyl alcohol	182 to 182	182	233 to 233	233				2400	20				1.0
dimethylphenol, 2,4-	2.0 to 6.9	2.0	2.0 to 6.9	2.0	850			160	10	0.32	EAD 604	421	3.4
methylphenol, 2- (o-cresol)	7.1 to 35	7.1	7.1 to 35	7.1				400	10	0.026	NERL 528		4.9
methylphenol, 4- (p-cresol)	77 to 77	77	77 to 77	77				40	10				1.0
pentachlorophenol	5.3 to 30	5.3	10 to 58	10	3.0	7.9	8	0.73	50	0.032	NERL 515.1	0.56	5.7
phenol (total)	78 to 729	78	224 to 2083	224	1,700,000			4800	10			21695	9.3
Arsenic, inorganic	36 to 2651	227	59 to 4326	370	0.14	36	36	0.058	1			0.00062	74
Cadmium	2.6 to 785	2.6	3.4 to 1031	3.4		9.3	8.8	8.0	0.2				307
Chromium, total	306 to 306	306	318 to 318	318		50	50	48	1				1.0

Table 4. Summary of Groundwater Screening Levels (Based on Sediment SQSs)

Chemical	Range of GW Screening Levels Based on SQS (ug/L)	GWSL based on SQS and best estimate K_{oc}/K_d (ug/L)	Range of GW Screening Levels Based on CSL (ug/L)	GWSL based on CSL and best estimate Koc/Kd (ug/L)	AWQC (ug/L) (HH; organism only) (a)	WA Marine Water Quality Criteria (b)	EPA Marine Chronic Water Quality Criteria (ecological receptors; ug/L) (a)	MTCA Method B GW Cleanup Level (ug/L)	Typical Method Detection Limit (MDL) (ug/L) (c)	Lowest Method Detection Limit (MDL) (ug/L) (d)	Analytical Method that will Achieve GWSL (e)	Ratio of AWQC to GWSL	Ratio of Max to Min GWSLs
Copper	123 to 17727	123	123 to 17727	123		**3.1**	**3.1**	590	25				144
Lead	11 to 500	11	13 to 589	13		**8.1**	**8.1**	15	3				44
Mercury	0.0052 to 41	0.0052	0.0074 to 59	0.0074	0.051	0.025	0.94	4.8	**0.2**	0.0002	EAD 1631	9.9	7943
Silver	1.5 to 15250	1.5	1.5 to 15250	1.5				80	0.5				9953
Zinc	33 to 10250	33	76 to 24000	76	26,000	81	81	4800	20			798	315

(a) National Recommended Water Quality Criteria, USEPA Office of Water. 2006.
(b) WAC 173-201A-240, Toxic Substances. Table 240(3).
(c) MDLs for Methods EPA-8270 (SVOCs), EPA-505 (PCBs), various (metals)
(d) Lowest MDLs are based on EPA method with lowest DL as reported in the National Environmental Methods Index (NEMI) (www.nemi.gov)
(e) Alternate analytical method listed for all chemicals with typical MDL greater than GWSL (Column E). EAD = USEPA Engineering Analysis Division;
NERL = USEPA National Exposure Research Laboratory drinking water method; OGWDW = USEPA Office of Groundwater and Drinking Water

Calculated GWSL > Criterion (AWQC, Marine WQC, or MTCA Method B)
Calculated GWSL < Method Detection Limit

Table 5. Henry's Law Constant (H)

Chemical - NonIonizing Organics	H (a)	H (b)
acenaphthene	7.44E-03	6.36E-03
acenaphthylene	5.11E-03	
anthracene	2.27E-03	2.67E-03
benzo(g,h,i)perylene	1.35E-05	
benzo[a]anthracene	4.91E-04	1.37E-04
benzo[a]pyrene	1.87E-05	4.63E-05
benzo[b]fluoranthene	2.69E-05	4.55E-03
benzo[k]fluoranthene	2.39E-05	3.40E-05
bis(2-ethylhexyl) phthalate	1.10E-05	4.18E-06
butyl benzyl phthalate	5.15E-04	5.17E-05
chrysene	2.14E-04	3.88E-03
dibenz[a,h]anthracene	5.03E-06	6.03E-07
dibenzofuran	8.71E-03	
di-butyl phthalate (di-n-butyl phth.)	7.40E-05	3.85E-08
dichlorobenzene, 1,2-	7.85E-02	7.79E-02
dichlorobenzene, 1,4-	9.85E-02	9.96E-02
diethyl phthalate	2.49E-05	1.85E-05
dimethyl phthalate	4.29E-06	
di-n-octyl phthalate	1.05E-04	2.74E-03
fluoranthene	3.62E-04	6.60E-04
fluorene	3.93E-03	2.61E-03
hexachlorobenzene	6.95E-02	5.41E-02
hexachlorobutadiene	4.21E-01	3.34E-01
indeno[1,2,3-cd]pyrene	1.42E-05	6.56E-05
methylnaphthalene, 2-	2.12E-02	
naphthalene	1.80E-02	1.98E-02
nitrosodiphenylamine, N-	4.95E-05	2.05E-04
pcb mixtures	1.40E-02	
pcb - Aroclor 1016	1.40E-02	
pcb - Aroclor 1248	1.40E-02	
pcb - Aroclor 1254	1.40E-02	
pcb - Aroclor 1260	1.40E-02	
phenanthrene	1.73E-03	
pyrene	4.87E-04	4.51E-04
trichlorobenzene, 1,2,4-	5.81E-02	5.82E-02
Chemical -- Ionizing Organics	**H (a)**	**H (b)**
benzoic acid	1.56E-06	
benzyl alcohol	1.38E-05	
dimethylphenol, 2,4-	3.89E-05	
methylphenol, 2- (o-cresol)	4.91E-05	
methylphenol, 4- (p-cresol)	4.09E-05	
pentachlorophenol	1.00E-06	
phenol (total)	1.36E-05	

(a) Values were taken from
http://www.epa.gov/oppt/exposure/docs/episuitedl.htm (See text, Section 2.1)
(b) Soil Screening Guidance 2002

Table 6. Summary of Vadose Zone Soil Screening Levels (Based on Sediment SQS)

Chemical	Range of Soil Screening Values Based on SQS (mg/kg)	SSL based on SQS and best estimate GWSL (mg/kg DW)	Range of Soil Screening Values Based on CSL (mg/kg)	SSL based on CSL and best estimate GWSL (mg/kg DW)	MTCA A (Unrestricted)	MTCA A (Industrial)	MTCA B (Unrestricted) (mg/kg DW)	MTCA C (Industrial) (mg/kg DW)	Typical Method Detection Limit (MDL) (mg/kg)	Lowest Method Detection Limit (MDL) (mg/kg)	Analytical Method that will Achieve SSL (a)	SQS (mg/kg OC)	CSL converted to dry weight conc'n (mg/kg DW)*	Ratio of SSL (DW) to SQS (DW)
acenaphthene	0.33 to 0.33	0.33	1.2 to 1.2	1.2			4800	210000	0.02			16	0.3	1.0
acenaphthylene	1.4 to 1.4	1.4	1.4 to 1.4	1.4					0.02			66	1.3	1.0
anthracene	4.4 to 4.4	4.4	24 to 24	24			24000	1100000	0.66			220	4.4	1.0
benzo(g,h,i)perylene	0.62 to 0.62	0.62	1.6 to 1.6	1.6					0.02			31	0.6	1.0
benzo[a]anthracene	2.2 to 2.2	2.2	5.4 to 5.4	5.4			**0.14**	18	0.02			110	2.2	1.0
benzo[a]pyrene	2.0 to 2.0	2.0	4.2 to 4.2	4.2	**0.1**	**2**	**0.14**	18	0.02			99	2.0	1.0
benzo[b]fluoranthene	4.6 to 4.6	4.6	9.0 to 9.0	9.0			**0.14**	18	0.02			230	4.6	1.0
benzo[k]fluoranthene	4.6 to 4.6	4.6	9.0 to 9.0	9.0			**0.14**	18	0.02			230	4.6	1.0
bis(2-ethylhexyl) phthalate	0.94 to 0.94	0.94	1.6 to 1.6	1.6			71	9400	0.02			47	0.9	1.0
butyl benzyl phthalate	0.10 to 0.10	0.10	1.3 to 1.3	1.3			16000	700000	0.02			4.9	0.10	1.0
chrysene	2.2 to 2.2	2.2	9.2 to 9.2	9.2			**0.14**	18	0.02			110	2.2	1.0
dibenz[a,h]anthracene	0.24 to 0.24	0.24	0.66 to 0.66	0.66			**0.14**	18	0.02			12	0.24	1.0
dibenzofuran	0.31 to 0.31	0.31	1.2 to 1.2	1.2			160	7000	0.02			15	0.30	1.0
di-butyl phthalate (di-n-butyl phth.)	4.4 to 5.0	5.0	34 to 39	39			8000	350000	0.02			220	4.4	1.1
dichlorobenzene, 1,2-	0.061 to 0.071	0.068	0.061 to 0.071	0.068			4000	180000	0.0032			2.3	0.046	1.5
dichlorobenzene, 1,4-	0.083 to 0.092	0.092	0.24 to 0.27	0.27			400	18000	0.0032			3.1	0.06	1.5
diethyl phthalate	2.1 to 4.2	3.2	3.7 to 7.6	5.7			64000	2800000	0.02			61	1.2	2.6
dimethyl phthalate	1.6 to 1.6	1.6	1.6 to 1.6	1.6			80000	3500000	0.02			53	1.1	1.5
di-n-octyl phthalate	1.2 to 1.2	1.2	90 to 90	90			1600	70000	0.02			58	1.2	1.0
fluoranthene	3.2 to 3.2	3.2	24 to 24	24			3200	140000	0.02			160	3.2	1.0
fluorene	0.47 to 0.47	0.47	1.6 to 1.6	1.6			3200	140000	0.02			23	0.46	1.0
hexachlorobenzene	0.0076 to 0.0081	0.0076	0.046 to 0.049	0.046			0.6	82	**0.012**	0.001	NST 130.00	0.38	0.008	1.0
hexachlorobutadiene	0.078 to 0.10	0.10	0.12 to 0.15	0.15			13	700	0.02			3.9	0.08	1.2
indeno[1,2,3-cd]pyrene	0.68 to 0.68	0.68	1.8 to 1.8	1.8			**0.14**	18	0.02			34	0.68	1.0
methylnaphthalene, 2-	0.83 to 0.83	0.83	1.4 to 1.4	1.4			320	14000	0.02			38	0.76	1.1
naphthalene	2.2 to 2.3	2.2	3.7 to 4.0	3.8	5	5	1600	70000	0.02			99	2.0	1.1
nitrosodiphenylamine, N-	0.23 to 0.25	0.23	0.23 to 0.25	0.23			200	27000	0.012			11	0.22	1.0
pcb mixtures	0.24 to 0.24	0.24	1.3 to 1.3	1.3	1	10	**0.50**	66				12	0.24	1.0
pcb - Aroclor 1016	0.24 to 0.24	0.24	1.3 to 1.3	1.3			5.6	250	0.0033			12	0.24	1.0
pcb - Aroclor 1248	0.24 to 0.24	0.24	1.3 to 1.3	1.3					0.0033			12	0.24	1.0
pcb - Aroclor 1254	0.24 to 0.24	0.24	1.3 to 1.3	1.3			1.6	70	0.0033			12	0.24	1.0
pcb - Aroclor 1260	0.24 to 0.24	0.24	1.3 to 1.3	1.3					0.0033			12	0.24	1.0
phenanthrene	2.0 to 2.0	2.0	9.7 to 9.7	9.7					0.02			100	2.0	1.0
pyrene	20 to 20	20	28 to 28	28			2400	110000	0.02			1000	20	1.0
trichlorobenzene, 1,2,4-	0.018 to 0.021	0.021	0.040 to 0.046	0.046			800	35000	0.006			0.81	0.016	1.3
benzoic acid	10 to 226	9.6	10 to 226	9.6			320000	14000000	0.1			NA	0.65	15
benzyl alcohol	0.78 to 0.78	0.78	1.0 to 1.0	1.0			24000	1100000	0.006			NA	0.057	14
dimethylphenol, 2,4-	0.037 to 0.057	0.037	0.037 to 0.057	0.037			1600	70000	0.02			NA	0.029	1.3
methylphenol, 2- (o-cresol)	0.091 to 0.20	0.091	0.091 to 0.20	0.091			4000	180000	0.02			NA	0.063	1.5
methylphenol, 4- (p-cresol)	0.98 to 0.98	0.98	0.98 to 0.98	0.98			400	18000	0.02			NA	0.67	1.5
pentachlorophenol	0.38 to 0.48	0.38	0.73 to 0.92	0.73			8.3	1100	0.061			NA	0.36	1.1
phenol (total)	0.73 to 3.3	0.73	2.1 to 9.5	2.1			48000	2100000	0.02			NA	0.42	1.7
Arsenic, inorganic	16 to 84047	7194	25 to 137129	11737			**0.67**	88	0.91			NA	57	126
Cadmium	0.34 to 31313	26	0.45 to 41137	34			80	3500	0.065			NA	5.1	5.0
Chromium, total	5201 to 5201	5201	5401 to 5401	5401			**240**	11000	0.58			NA	260	20

Table 6. Summary of Vadose Zone Soil Screening Levels (Based on Sediment SQS)

August 2006 (Revised February 2007)

Chemical	Range of Soil Screening Values Based on SQS (mg/kg)	SSL based on SQS and best estimate GWSL (mg/kg DW)	Range of Soil Screening Values Based on CSL (mg/kg)	SSL based on CSL and best estimate GWSL (mg/kg DW)	MTCA A (Unrestricted)	MTCA A (Industrial)	MTCA B (Unrestricted) (mg/kg DW)	MTCA C (Industrial) (mg/kg DW)	Typical Method Detection Limit (MDL) (mg/kg)	Lowest Method Detection Limit (MDL) (mg/kg)	Analytical Method that will Achieve SSL (a)	SQS (mg/kg OC)	CSL converted to dry weight conc'n (mg/kg DW)*	Ratio of SSL (DW) to SQS (DW)
Copper	55 to 1121242	780	55 to 1121242	780			3000	130000	0.18			NA	390	2.0
Lead	204 to 398109	1133	240 to 468884	1335					0.44			NA	450	2.5
Mercury	0.0011 to 65135	0.41	0.0015 to 93731	0.59			24	1100	0.011			NA	0.41	1.0
Silver	0.018 to 1214288	12	0.018 to 1214288	12					0.17			NA	6.1	2.0
Zinc	26 to 2580838	327	61 to 6042938	765			24000	1100000	0.66			NA	410	0.80

*Assumes foc in sediment = 0.02

MDLs are from various sources including local laboratories and method descriptions. Actual MDLs may differ based on sample-specific factors.

Calculated SSL > Criterion (MTCA Method B, MTCA Method C)
Calculated SSL < Method Detection Limit

NA = Not Applicable

(a) Alternate analytical method listed for all chemicals with typical MDL greater than SSL (Column E). NST = National Oceanic & Atmospheric Administration method

Table 7. Summary of Saturated Zone Soil Screening Levels (Based on Sediment SQS)

Chemical	Range of Soil Screening Values Based on SQS (mg/kg)	SSL based on SQS and best estimate GWSL (mg/kg DW)	Range of Soil Screening Values Based on CSL (mg/kg)	SSL based on CSL and best estimate GWSL (mg/kg DW)	MTCA A (Unrestricted)	MTCA A (Industrial)	MTCA B (Unrestricted) (mg/kg DW)	MTCA C (Industrial) (mg/kg DW)	Typical Method Detection Limit (MDL) (mg/kg)	Lowest Method Detection Limit (MDL) (mg/kg)	Analytical Method that will Achieve SSL (a)	SQS (mg/kg OC)	SQS converted to dry weight conc'n (mg/kg DW)*	Ratio of SSL (DW) to SQS (DW)
acenaphthene	0.017 to 0.017	0.017	0.059 to 0.060	0.060			4800	210000	0.02	0.0005	NST 130.30	16	0.32	0.052
acenaphthylene	0.069 to 0.069	0.069	0.069 to 0.069	0.069					0.02			66	1.3	0.052
anthracene	0.22 to 0.22	0.22	1.2 to 1.2	1.2			24000	1100000	0.66	0.0023	NST 130.30	220	4.4	0.051
benzo(g,h,i)perylene	0.031 to 0.031	0.031	0.078 to 0.078	0.078					0.02			31	0.62	0.050
benzo[a]anthracene	0.11 to 0.11	0.11	0.27 to 0.27	0.27			0.14	18	0.02			110	2.2	0.050
benzo[a]pyrene	0.10 to 0.10	0.10	0.21 to 0.21	0.21	0.1	2	0.14	18	0.02			99	2.0	0.050
benzo[b]fluoranthene	0.23 to 0.23	0.23	0.45 to 0.45	0.45			0.14	18	0.02			230	4.6	0.050
benzo[k]fluoranthene	0.23 to 0.23	0.23	0.45 to 0.45	0.45			0.14	18	0.02			230	4.6	0.050
bis(2-ethylhexyl) phthalate	0.047 to 0.047	0.047	0.078 to 0.078	0.078			71	9400	0.02			47	0.94	0.050
butyl benzyl phthalate	0.0049 to 0.0051	0.0051	0.064 to 0.066	0.066			16000	700000	0.02	0.02	EPA 8270C	4.9	0.10	0.052
chrysene	0.11 to 0.11	0.11	0.46 to 0.46	0.46			0.14	18	0.02			110	2.2	0.050
dibenz[a,h]anthracene	0.012 to 0.012	0.012	0.033 to 0.033	0.033			0.14	18	0.02	0.0004	NST 130.30	12	0.24	0.050
dibenzofuran	0.015 to 0.015	0.015	0.059 to 0.059	0.059			160	7000	0.02	0.02	EPA 8270C	15	0.30	0.051
di-butyl phthalate (di-n-butyl phth.)	0.22 to 0.26	0.26	1.7 to 2.0	2.0			8000	350000	0.02			220	4.4	0.060
dichlorobenzene, 1,2-	0.0034 to 0.0040	0.0038	0.0034 to 0.0040	0.0038			4000	180000	0.0032			2.3	0.046	0.082
dichlorobenzene, 1,4-	0.0045 to 0.0051	0.0051	0.013 to 0.015	0.015			400	18000	0.0032			3.1	0.062	0.083
diethyl phthalate	0.12 to 0.27	0.20	0.22 to 0.49	0.36			64000	2800000	0.02			61	1.2	0.16
dimethyl phthalate	0.094 to 0.094	0.094	0.094 to 0.094	0.094			80000	3500000	0.02			53	1.1	0.089
di-n-octyl phthalate	0.058 to 0.058	0.058	4.5 to 4.5	4.5			1600	70000	0.02			58	1.2	0.050
fluoranthene	0.16 to 0.16	0.16	1.2 to 1.2	1.2			3200	140000	0.02			160	3.2	0.050
fluorene	0.023 to 0.024	0.024	0.081 to 0.082	0.081			3200	140000	0.02			23	0.46	0.051
hexachlorobenzene	0.0004 to 0.0004	0.0004	0.0023 to 0.0025	0.0023			0.6	82	0.012	0.00005	NST 130.00	0.38	0.0076	0.054
hexachlorobutadiene	0.0039 to 0.0050	0.0050	0.0062 to 0.0080	0.0080			13	700	0.02	0.02	EPA 8270C	3.9	0.078	0.064
indeno[1,2,3-cd]pyrene	0.034 to 0.034	0.034	0.088 to 0.088	0.088			0.14	18	0.02			34	0.68	0.050
methylnaphthalene, 2-	0.043 to 0.043	0.043	0.073 to 0.073	0.073			320	14000	0.02			38	0.76	0.057
naphthalene	0.11 to 0.12	0.11	0.19 to 0.21	0.20	5	5	1600	70000	0.02			99	2.0	0.058
nitrosodiphenylamine, N-	0.012 to 0.013	0.012	0.012 to 0.013	0.012			200	27000	0.012			11	0.22	0.053
pcb mixtures	0.012 to 0.012	0.012	0.065 to 0.065	0.065	1	10	0.50	66				12	0.24	0.050
pcb - Aroclor 1016	0.012 to 0.012	0.012	0.065 to 0.066	0.066			5.6	250	0.0033			12	0.24	0.051
pcb - Aroclor 1248	0.012 to 0.012	0.012	0.065 to 0.065	0.065					0.0033			12	0.24	0.050
pcb - Aroclor 1254	0.012 to 0.012	0.012	0.065 to 0.065	0.065			1.6	70	0.0033			12	0.24	0.050
pcb - Aroclor 1260	0.012 to 0.012	0.012	0.065 to 0.065	0.065					0.0033			12	0.24	0.050
phenanthrene	0.10 to 0.10	0.10	0.49 to 0.49	0.49					0.02			100	2.0	0.051
pyrene	1.0 to 1.0	1.0	1.4 to 1.4	1.4			2400	110000	0.02			1000	20	0.050
trichlorobenzene, 1,2,4-	0.0009 to 0.0011	0.0011	0.0021 to 0.0025	0.0025			800	35000	0.006	0.001	EPA 8260	0.81	0.016	0.070
benzoic acid	0.68 to 16	0.68	0.68 to 16	0.68			320000	14000000	0.1			NA	0.65	1.0
benzyl alcohol	0.055 to 0.055	0.055	0.070 to 0.070	0.070			24000	1100000	0.006			NA	0.057	0.97
dimethylphenol, 2,4-	0.0020 to 0.0034	0.0020	0.0020 to 0.0034	0.0020			1600	70000	0.07	0.02	EPA 8270C	NA	0.029	0.070
methylphenol, 2- (o-cresol)	0.0052 to 0.013	0.0052	0.0052 to 0.013	0.0052			4000	180000	0.07	0.02	EPA 8270C	NA	0.063	0.082
methylphenol, 4- (p-cresol)	0.056 to 0.056	0.056	0.056 to 0.056	0.056			400	18000	0.02			NA	0.67	0.083
pentachlorophenol	0.020 to 0.027	0.020	0.037 to 0.051	0.037			8.3	1100	0.061	0.061	EPA 8270C	NA	0.36	0.054
phenol (total)	0.043 to 0.23	0.04	0.12 to 0.66	0.12			48000	2100000	0.02			NA	0.42	0.10
Arsenic, inorganic	0.78 to 4203	360	1.3 to 6857	587			0.67	88	0.91			NA	57	6.3
Cadmium	0.017 to 1566	1.3	0.023 to 2057	1.7			80	3500	0.065			NA	5.1	0.25
Chromium, total	260 to 260	260	270 to 270	270			240	11000	0.58			NA	260	1.0

Table 7. Summary of Saturated Zone Soil Screening Levels (Based on Sediment SQS)

Chemical	Range of Soil Screening Values Based on SQS (mg/kg)	SSL based on SQS and best estimate GWSL (mg/kg DW)	Range of Soil Screening Values Based on CSL (mg/kg)	SSL based on CSL and best estimate GWSL (mg/kg DW)	MTCA A (Unrestricted)	MTCA A (Industrial)	MTCA B (Unrestricted) (mg/kg DW)	MTCA C (Industrial) (mg/kg DW)	Typical Method Detection Limit (MDL) (mg/kg)	Lowest Method Detection Limit (MDL) (mg/kg)	Analytical Method that will Achieve SSL (a)	SQS (mg/kg OC)	SQS converted to dry weight conc'n (mg/kg DW)*	Ratio of SSL (DW) to SQS (DW)
Copper	2.7 to 56064	39	2.7 to 56064	39			3000	130000	0.18			NA	390	0.10
Lead	10 to 19906	57	12 to 23444	67					0.44			NA	450	0.13
Mercury	0.00005 to 3257	0.021	0.00008 to 4687	0.030			24	1100	0.011			NA	0.41	0.050
Silver	0.0011 to 60716	0.61	0.0011 to 60716	0.61					0.17			NA	6.1	0.10
Zinc	1.3 to 129043	16	3.1 to 302149	38			24000	1100000	0.66			NA	410	0.040

*Assumes foc in sediment = 0.020

MDLs are from various sources including local laboratories and method descriptions. Actual MDLs may differ based on sample-specific factors.

Calculated SSL > Criterion (MTCA Method B, MTCA Method C)
Calculated SSL < Method Detection Limit

NA = Not Applicable

(a) Alternate analytical method listed for all chemicals with typical MDL greater than SSL (Column E). NST = National Oceanic & Atmospheric Administration method